

Claims

- [c1] 1.A process for converting hydrocarbon fuel to hydrogen and carbon monoxide as main reaction products comprising:
- providing a reactor comprising:
 - a reactor shell having an inlet and an outlet and forming a reaction flow passage extending from the inlet to the outlet, the reactor shell also forming a catalytic reaction zone between the inlet and the outlet, a pre-reaction zone upstream of the catalytic reaction zone, and a post-reaction zone downstream of the catalytic reaction zone; and
 - a catalytic structure disposed in the catalytic reaction zone comprising an oxidation catalyst supported on an open-channel support;
 - feeding a feed gas mixture comprising an oxygen containing gas and a hydrocarbon fuel through the inlet, along the reaction flow passage, and through the catalytic structure;
 - maintaining the catalytic reaction zone at a temperature sufficient to convert the feed gas mixture to an exit gas stream containing hydrogen and carbon monoxide as main reaction products; and

cooling the pre- reaction zone adjacent the catalytic reaction zone to maintain the temperature of the feed gas mixture below the flash point of the feed gas mixture until the feed gas mixture enters the catalytic reaction zone.

- [c2] 2.A process as in claim 1 wherein the cooling is radiant cooling.
- [c3] 3.A process as in claim 1 wherein the cooling is convective cooling.
- [c4] 4.A process as in claim 1 wherein the cooling is carried out with a heat exchanger.
- [c5] 5.A process as in claim 1 wherein the cooling maintains the temperature of the feed gas mixture below 500 °C.
- [c6] 6.A process as in Claim 1 wherein the cooling maintains the temperature of the feed gas mixture below 300 °C.
- [c7] 7.The process of Claim 1, wherein said hydrocarbon fuel is a heavy hydrocarbon fuel.
- [c8] 8.The process of Claim 7, wherein said heavy hydrocarbon fuel is selected from the group consisting of gasoline, kerosene, jet fuel, and diesel fuel.
- [c9] 9.The process of Claim 1, wherein catalytic structure is

maintained at a temperature greater than about 900°C.

[c10] 10. The process of Claim 1, wherein said oxygen containing gas comprises air.

[c11] 11. A process for converting hydrocarbon fuel to hydrogen and carbon monoxide as main reaction products comprising:

providing a reactor including:

a reactor shell having an inlet and an outlet and forming a reaction flow passage extending from the inlet to the outlet, the reactor shell also forming a catalytic reaction zone between the inlet and the outlet, a pre-reaction zone upstream of the catalytic reaction zone, and a post-reaction zone downstream of the catalytic reaction zone; and

a catalytic structure disposed in the catalytic reaction zone comprising an oxidation catalyst supported on an open-channel support;

feeding a feed gas mixture comprising an oxygen containing gas and a heavy hydrocarbon fuel through the inlet, along the reaction flow passage, and through the catalytic structure;

maintaining the catalytic reaction zone at a temperature sufficient to convert the feed gas mixture to an exit gas stream containing hydrogen and carbon monoxide as main reaction products; and

maintaining the exit gas stream in the post-reaction zone adjacent the catalytic reaction zone at a temperature greater than about 600 °C until the conversion of the feed gas mixture to hydrogen and carbon monoxide is substantially entirely complete.

[c12] 12.A process as in Claim 11 wherein the reactor includes a post-reaction radiation shield disposed in the reaction flow passage adjacent to and downstream of the catalytic support and the temperature of the exit gas stream is maintained at greater than about 600 °C through the post-reaction radiation shield and for a distance downstream of the post-reaction radiation shield.

[c13] 13.A process as in Claim 11 wherein the exit gas stream is maintained at a temperature greater than about 700 °C until the conversion of the feed gas mixture to hydrogen and carbon monoxide is substantially entirely complete.

[c14] 14.A process as in Claim 11, wherein said hydrocarbon fuel is a heavy hydrocarbon fuel.

[c15] 15.A process as in Claim 14, wherein said heavy hydrocarbon fuel is selected from the group consisting of gasoline, kerosene, jet fuel, and diesel fuel.

[c16] 16.A process as in Claim 11, wherein catalytic structure is maintained at a temperature greater than about 900°C.

[c17] 17.A process for converting hydrocarbon fuel to hydrogen and carbon monoxide as main reaction products comprising:

- providing a reactor including:
 - a reactor shell having an inlet and an outlet and forming a reaction flow passage extending from the inlet to the outlet, the reactor shell also forming a catalytic reaction zone between the inlet and the outlet, a pre-reaction zone upstream of the catalytic reaction zone, and a post reaction zone downstream of the catalytic reaction zone;
 - and
 - a catalytic structure disposed in the catalytic reaction zone comprising an oxidation catalyst supported on an open-channel support;
- feeding a feed gas mixture comprising an oxygen containing gas and a heavy hydrocarbon fuel through the inlet, along the reaction flow passage, and through the catalytic structure;
- maintaining the catalytic reaction zone at a temperature sufficient to convert the feed gas mixture to an exit gas stream containing hydrogen and carbon monoxide as main reaction products;
- cooling the pre-reaction zone adjacent the catalytic reaction zone to maintain the temperature of the feed gas mixture below the flash point of the feed gas mixture

until the feed gas mixture enters the catalytic reaction zone; and
maintaining the exit gas stream in the post-reaction zone adjacent the catalytic reaction zone at a temperature greater than about 600 °C until the conversion of the feed gas mixture to hydrogen and carbon monoxide is substantially entirely complete.

[c18] 18.A process as in Claim 17 wherein the exit gas stream is maintained at a temperature greater than about 700 °C until the conversion of the feed gas mixture to hydrogen and carbon monoxide is substantially entirely complete.

[c19] 19.A process as in Claim 17 wherein the hydrocarbon fuel is a heavy hydrocarbon fuel and further comprising the step of introducing the hydrocarbon fuel into the feed gas mixture with a fine mist spray nozzle.

[c20] 20.A process as in Claim 19 the hydrocarbon fuel is a heavy hydrocarbon fuel and further comprising preheating the heavy hydrocarbon fuel to a temperature greater than 180 °C and less than the flash point of the feed gas mixture before or during introduction of the heavy hydrocarbon fuel into the feed gas mixture with a fine mist spray nozzle.

[c21] 21. A process as in Claim 17 wherein the hydrocarbon

fuel is a heavy hydrocarbon fuel and the heavy hydrocarbon fuel is introduced at a rate within a range from about 2 ml to about 50 ml.

[c22] 22.A process as in Claim 17, wherein said feed gas mixture being essentially free of water.

[c23] 23.A process as in Claim 17, wherein catalytic structure is maintained at a temperature greater than about 900°C.

[c24] 24.A process as in Claim 17, wherein a catalyst contact time in said catalyst structure is not greater than about 500 milliseconds and a liquid hourly space velocity in said catalyst structure is no less than about 0.5 h^{-1} .

[c25] 25.A process as in Claim 17, wherein a carbon to oxygen atom ratio in said feed gas mixture is no less than about 0.5.

[c26] 26.A process as in Claim 17, wherein the hydrocarbon fuel is a heavy hydrocarbon fuel and said heavy hydrocarbon fuel comprises a plurality of hydrocarbon molecules, with substantially all of said molecules each containing at least 6 carbon atoms.

[c27] 27.A process as in Claim 17, wherein the hydrocarbon fuel is a heavy hydrocarbon fuel and said heavy hydrocarbon fuel is selected from the group consisting of

gasoline, kerosene, jet fuel, and diesel fuel.

[c28] 28.A process as in Claim 17, wherein said process deposits less than about 1 atom% of total carbon in said hydrocarbon fuel as elemental carbon and carbon-rich compounds.

[c29] 29.A reactor for converting hydrocarbon fuel to hydrogen and carbon monoxide as main reaction products comprising:

a reactor shell having an inlet and an outlet and forming a reaction flow passage extending from the inlet to the outlet, the reactor shell also forming a catalytic reaction zone between the inlet and the outlet, a pre-reaction zone upstream of the catalytic reaction zone, and a post-reaction zone downstream of the catalytic reaction zone; and

a catalytic structure disposed in the catalytic reaction zone comprising an oxidation catalyst supported on an open-channel support, so that when a feed gas mixture comprising an oxygen containing gas and the hydrocarbon fuel is fed through the inlet, said feed gas mixture passes along the reaction flow passage and through said catalytic structure, said feed gas mixture converts in the catalytic structure to an exit gas stream containing hydrogen and carbon monoxide as main reaction products, and the exit gas stream discharges through the outlet;

and

cooling means for cooling the pre-reaction zone adjacent the catalytic reaction zone to maintain the temperature of the feed gas mixture below the flash point of the feed gas mixture until the feed gas mixture enters the catalytic reaction zone.

[c30] 30.A reactor as in Claim 29 further comprising a pre-catalytic radiation shield disposed in the pre-reaction zone adjacent the catalytic structure, the cooling means positioned for cooling the pre-catalytic radiation shield.

[c31] 31.A reactor as in Claim 29 wherein the cooling means is radiant.

[c32] 32.A reactor as in Claim 29 wherein the cooling means is convective.

[c33] 33.A reactor as in Claim 29 wherein the cooling means is a heat exchanger.

[c34] 34.A reactor for converting hydrocarbon fuel to hydrogen and carbon monoxide as main reaction products comprising:

a reactor shell having an inlet and an outlet and forming a reaction flow passage extending from the inlet to the outlet, the reactor shell also forming a catalytic reaction zone between the inlet and the outlet, a pre-reaction

zone upstream of the catalytic reaction zone, and a post-reaction zone downstream of the catalytic reaction zone;

a catalytic structure disposed in the catalytic reaction zone comprising an oxidation catalyst supported on an open-channel support, so that when a feed gas mixture comprising an oxygen containing gas and the hydrocarbon fuel is fed through the inlet, said feed gas mixture passes along the reaction flow passage and through said catalytic structure, said feed gas mixture converts in the catalytic structure to an exit gas stream containing hydrogen and carbon monoxide as main reaction products, and the exit gas stream discharges through the outlet; and

insulation for maintaining the exit gas stream in the post-reaction zone adjacent the catalytic reaction zone at a temperature greater than about 600 °C until the conversion of the feed gas mixture to hydrogen and carbon monoxide is substantially entirely complete.

- [c35] 35.A reactor as in Claim 34 wherein the insulation maintains the exit gas stream in the post-reaction zone adjacent the catalytic reaction zone at a temperature greater than about 700 °C until the conversion of the feed gas mixture to hydrogen and carbon monoxide is substantially entirely complete.

[c36] 36.A reactor as in Claim 31 further comprising a post-reaction radiation shield disposed in the post-reaction zone adjacent to and downstream of the catalytic support and wherein insulation insulates the post-reaction zone proximate the post-reaction radiation shield and for a distance downstream of the post-reaction radiation shield.

[c37] 37.A reactor for converting hydrocarbon fuel to hydrogen and carbon monoxide as main reaction products comprising:
a reactor shell having an inlet and an outlet and forming a reaction flow passage extending from the inlet to the outlet, the reactor shell also forming a catalytic reaction zone between the inlet and the outlet, a pre-reaction zone upstream of the catalytic reaction zone, and a post reaction zone downstream of the catalytic reaction zone;
a catalytic structure disposed in the catalytic reaction zone comprising an oxidation catalyst supported on an open-channel support, so that when a feed gas mixture comprising an oxygen containing gas and the hydrocarbon fuel is fed through the inlet, said feed gas mixture passes along the reaction flow passage and through said catalytic structure, said feed gas mixture converts in the catalytic structure to an exit gas stream containing hydrogen and carbon monoxide as main reaction products,

and the exit gas stream discharges through the outlet; cooling means for cooling the pre-reaction zone adjacent the catalytic reaction zone to maintain the temperature of the feed gas mixture below the flash point of the feed gas mixture until the feed gas mixture enters the catalytic reaction zone; and insulation for maintaining the exit gas stream in the post-reaction zone adjacent the catalytic reaction zone at a temperature greater than about 600 °C until the conversion of the feed gas mixture to hydrogen and carbon monoxide is substantially entirely complete.

[c38] 38.A reactor as in Claim 37 wherein the insulation maintains the exit gas stream in the post-reaction zone adjacent the catalytic reaction zone at a temperature greater than about 700 °C until the conversion of the feed gas mixture to hydrogen and carbon monoxide is substantially entirely complete.

[c39] 39.A reactor as in Claim 37 further comprising:
a pre-reaction radiation shield disposed in the pre-reaction zone adjacent the catalytic structure, the cooling means positioned for cooling the pre-reaction radiation shield; and
a post-reaction radiation shield disposed in the post-reaction zone adjacent to and downstream of the catalytic structure and wherein insulation insulates the

post-reaction zone proximate the post-reaction radiation shield and for a distance downstream of the post-reaction radiation shield.

- [c40] 40. A system for producing electric power comprising:
- a reactor for the conversion of heavy hydrocarbon fuel to produce an exit gas stream containing hydrogen and carbon monoxide as main reaction products; and
 - a fuel cell disposed for receiving the exit gas stream and consuming the hydrogen to produce electric power,
- the reactor comprising:
- a reactor shell having an inlet and an outlet and forming a reaction flow passage extending from the inlet to the outlet, the reactor shell also forming a catalytic reaction zone between the inlet and the outlet, a pre-reaction zone upstream of the catalytic reaction zone, and a post-reaction zone downstream of the catalytic reaction zone; and
 - a catalytic structure disposed in the catalytic reaction zone comprising an oxidation catalyst supported on an open-channel support, so that when a feed gas mixture comprising an oxygen containing gas and the hydrocarbon fuel is fed through the inlet, said feed gas mixture passes along the reaction flow passage and through said catalytic structure, said feed gas mixture converts in the catalytic structure to an exit gas stream containing hy-

drogen and carbon monoxide as main reaction products, and the exit gas stream discharges through the outlet; and

cooling means for cooling the pre-reaction zone adjacent the catalytic reaction zone to maintain the temperature of the feed gas mixture below the flash point of the feed gas mixture until the feed gas mixture enters the catalytic reaction zone.

- [c41] 41.A system for producing electric power comprising:
a reactor for the catalytic partial oxidation of hydrocarbon fuel to produce an exit gas stream containing hydrogen and carbon monoxide as main reaction products; and
a fuel cell disposed for receiving the exit gas stream and consuming the hydrogen to produce electric power,
the reactor comprising:
a reactor shell having an inlet and an outlet and forming a reaction flow passage extending from the inlet to the outlet, the reactor shell also forming a catalytic reaction zone between the inlet and the outlet, a pre-reaction zone upstream of the catalytic reaction zone, and a post-reaction zone downstream of the catalytic reaction zone;
a catalytic structure disposed in the catalytic reaction zone comprising an oxidation catalyst supported on an

open-channel support, so that when a feed gas mixture comprising an oxygen containing gas and the hydrocarbon fuel is fed through the inlet, said feed gas mixture passes along the reaction flow passage and through said catalytic structure, said feed gas mixture converts in the catalytic structure to an exit gas stream containing hydrogen and carbon monoxide as main reaction products, and the exit gas stream discharges through the outlet; and

insulation for maintaining the exit gas stream in the post-reaction zone adjacent the catalytic reaction zone at a temperature greater than about 600 °C until the conversion of the feed gas mixture to hydrogen and carbon monoxide is substantially entirely complete.